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AN EXPERIMENTAL STUDY ON PERFORMANCE AND EMISSION CHARACTERISTIC OF A SINGLE CYLINDER FOUR STROKE OVER HEAD VALVE (OHV) SPARK IGNITION ENGINE

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ABSTRACT

This paper focuses on the experimental study on performance and emission characteristic of an existing single cylinder four stroke overhead valve (OHV) spark ignition engine. The main advantage of this project is to reduce weight of the overhead valve engine components in two ways, one is selection of material and, other is to optimize the design layout within the design region, by using topology optimization. At first, the performance and emission characteristics of the single cylinder four stroke overhead valve engines with the help of eddy current dynamo meter and standard silencer was studied. Based on the experimental results, brake power, specific fuel consumption, mechanical efficiency, brake thermal efficiency and indicated thermal efficiency are calculated by using governing equations, and the valves are plotted graphically. Another perspective view of the project is to study and record the emission characteristic such as carbon monoxide (CO), unburned hydrocarbons (HC) and carbon dioxide (CO2).

KEYWORDS: Over Head Valve (OHV) Engines, Topology Optimization, Brake Power, Mechanical Efficiency, Brake Thermal Efficiency & Indicated Thermal Efficiency

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Original Article

INTRODUCTION

Any type of engine or machine, which derives heat energy from combustion of fuel and converts this energy into mechanical work is known has heat engine. Heat engine may be classified into two types: one is External Combustion (EC) engine and other is Internal Combustion (IC) engine. Combustion of the fuel takes place outside the cylinder is known as EC engine, whereas, combustion of the fuel with oxygen of the air takes place inside the cylinder is termed as IC engine[1].

This paper discusses about the performance and emissions of a spark-ignited, port-injected, gasoline-fuelled, and water-cooled, small-size modern motorcycle engine, as investigated. Experimental tests were performed for a range of engine speeds, various air-fuel ratios with a WOT condition and fixed timing of injection and ignition events. The experimental test-rig results consist of torque, power, brake mean effective pressure (bmep), AFR and emissions of the exhaust gas for various engine-dynamometer speeds[2].

This author studied an experimental investigation on a single-cylinder four-stroke spark ignition engine operating with gasoline, to study the effect of hydrogen, in addition to fuel on its performance and emissions. The hydrogen was inducted in the air inlet manifold, with different volume ratios 24%, 26%, 27%, 28%, 29%, 31%, 35%, 37%, 49% of total intake volume. The engine test performance shows an improvement in thermal efficiency, as well as reduction in brake specific fuel consumption. The emission analysis shows a reduction in HC, and CO[3].

This paper describes the experimental investigation on performance and emission characteristics of a conventional four-cylinder spark ignition (SI) engine, operated on hydrogen and gasoline. The test results show that, the power loss occurs at low speed hydrogen operation, whereas high speed characteristics compete well with gasoline operation. NOx emission of hydrogen fuelled engine is about 10 times lower than gasoline fuelled engine[4].

This paper shows the performance tests conducted to study volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption investigated for carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NOx) and carbon dioxide (CO2). Experiments were conducted at different engine speeds between 2500-4500 rpm, maintaining throttle position of 50% throughout the experiments. The investigations revealed that blending DNS with P100 increases brake thermal efficiency, volumetric efficiency, brake power, torque and brake specific fuel consumption. The CO, HC, NOx and CO2 emissions in the exhaust decrease when compared to P100 operation[5].

This paper investigate the performance parameters such as torque, brake mean effective pressure, brake power, specific fuel consumption and thermal efficiency and exhaust emission such as CO, CO2, HC and NOx are also measured[6]. This study is involved with Computational Fluid Dynamics (CFD) assessment of urea decomposition rate, by adopting various urea injection angles and nozzle positions. Also, urea atomization and evaporation/decomposition to ammonia and ammonia distribution on tail pipe cross-sectional area are investigated. Exhaust tail pipe is fitted with guided pipe at different angles. Also, urea and air are injected at different pressures respectively, in the twin-flow nozzle. The CFD study indicates that, the ammonia conversion rate is well improved using guided pipe fitted at 30^o angle of inclination with exhaust tail pipe. The CFD analysis is validated by engine experiments. It was proven that, the conversion increased for the 5bar urea and 1bar air[7].

The authors carried out the study with selective catalysis over Mn/Ce/Al2O3 catalysts, which were prepared by sol-gel and combustion synthesis methodology. These catalysts were coated on honeycomb ceramic samples and characterized by Scanning Electron Microscope (SEM). The coated samples were tested in four stroke vertical single cylinder with constant speed water cooled direct injection CI engine. The results showed nearly 60%NO conversion[8].

Agriculture is the backbone of our country. In most of the remote villages, gasoline engines are used for various agricultural purposes. The agricultural engines play a vital role in suction of water through pumps. Since huge amount of power is needed for this process, the fuel (petrol) consumption is high, which in turn increases the cost of the fuel. The cost of this process can be reduced by using alternative fuels like kerosene. The commercial engine has to be designed, which is capable of running in both petrol as well as kerosene. There are many engines, commercially available in the market such as HONDA engine; BRIGGS AND STRATTON; KODAK GOLD and SUZIKI engine.

At first, Honda engine was selected, because of the availability and its maintenance and service. The engine can run in both petrol and kerosene. The kerosene cost is low, so customers prefer Honda engine.

The main objective of the project is to reduce the weight of the overhead valve spark ignition engine components.

There are possible ways to reduce the weight, by alternative material selection, reducing individual components size leading to major weight savings, and enabling technology to achieve greater weight reduction. Due to this, the engine performance is maximized and the emission effects are controlled. This paper focuses on the experimental study on performance and emission characteristic of an existing single cylinder four stroke overhead valve (OHV) spark ignition engine. Based on the experimental results, brake power, specific fuel consumption and the emission characteristics such as carbon monoxide (CO), unburned hydrocarbons (HC) and carbon dioxide (CO2) were noted.

EXPERIMENTAL: MATERIALS AND METHODS

General Review

The authors used variable compression ratio, single cylinder four stroke petrol engines coupled with eddy current dynamometer. A rope brake dynamometer is supplied with the engine. It indicates the load range 0-20 kg Make Harrison. The engine and the dynamometer are mounted on a solid M.S. Channel Base Frame. The various factors to be measured are as follows: (a) Fuel measurement: This is done by using burette, which is mounted on the control panel. The fuel tank is mounted on panel. The fuel is supplied to engine using a fuel line to fuel injection system. The amount of fuel consumed is determined by the change in the readings shown on the burette. (b) Temperature measurement: For heat balance analysis, the PT-100 sensors are connected at exhaust gas calorimeter and engine cooling[9].

A four- stroke, single-cylinder, water-cooled, SI engine (brake power 2.2 kW, rated speed 3000 A rpm) was coupled to an eddy current dynamometer for measuring brake power. Compression ratio of engine was varied (3 -9) with change of clearance volume by adjustment of cylinder head, threaded to cylinder of the engine. Engine speeds are varied from 2400 to 3000 rpm. Exhaust gas temperature is measured with iron-constantan thermocouples. Specific fuel consumption of engine was measured with burette method, while air consumption was measured with air box method. The cylinder bore 70 mm and the stroke of the piston was 66 mm. Recommended SI engine timing was 25^{o} a TDC. CO and UBHC emissions in engine exhaust were measured with Netel Chromatograph analyzer[10].

This paper presents the experimental Line diagram, and Villiers Engine is used. It consists of fabrication work for the hydrogen fuel supply. The four stroke single cylinder is a constant speed engine, which runs at 3000 RPM. The governor is attached to the engine, which regulates the petrol flow when there is a change in the load. The load is varied by the hydraulic dynamometer; the fuel flow is measured by means of 50cc burette and air flow by manometer. The one end is connected to orifice plate for supplying of hydrogen fuel, a separate arrangement is made and it consists of hydrogen cylinder which consists of hydrogen gas stored at 140 Bars connected to a surge tank[11].

The performance enhancement characteristics at various loads were observed, using air preheating for a four stroke spark ignition engine. The concept of air pre heating shown to have many advantages in helping the engine for a cold start, heating the atmospheric air will remove extreme vapor present in it, which may lead to improper flame propagation. The fuel mixed with the heated air will burn completely in the combustion chamber, thus reducing the amount of un-burnt particles[12].

This paper presents, experimental investigation done by producing biodiesel from groundnut oil and mixing it in various ratios with diesel to run a Single Cylinder Field Marshall Diesel engine and attaining the different performance and emission characteristics for the Biodiesel. The experiment was carried out in a Single Cylinder Field Marshall CI Engine, operating at a constant speed of 1000 rpm. The engine was not given a protective coating, so as to also explore the feasibility of its commercial application. Hence, the tests were done for mixtures up to 50 percentage ratio of Biodiesel to

Diesel only, as any more could lead to clogging of the engine parts[14].

The aim of the author is to experimentally investigate the influence of fuel oil –diesel blending on performance and emission in single cylinder compression ignition engines. This study has been conducted at single cylinder diesel engine YANMAR TF120 with 0.63 L and 17.7 compression ratio with Hydrome model HGP-3A-F23 dynamometer. The exhaust gas analyzer is also included in the engine test bed. The experiment was conducted with five speeds from 1200 rpm to 2400 rpm with intervals of 300 rpm and engine load 25%. The Fuel Consumption (FC), torque, engine power, volumetric efficiency, exhaust temperature, and emissions (CO2, CO and NOx) have been measured in the experiment. The engine power, speeds, torques, fuel consumptions and volumetric efficiency were measured. The engine emissions (CO), (CO2), (NOx) emissions, engine temperature and in -cylinder pressure were analyzed[15].

Engine Specification

To perform the task, the experimental test rig consisted of fuel gauge manometer, dynamo meter, single cylinder four stroke OHV spark ignition engine, fuel tank and performance meter. The organization of the experimental set up is as shown in figure 1.

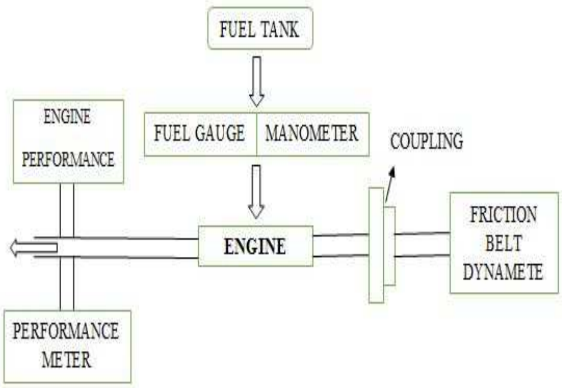


Figure 1: Organization of Experimental Setup

The test was performed in two stages: At first, engine was tested petrol start – petrol run. Secondly, the engine was tested petrol start – kerosene run. The engine specification and properties of fuel are listed in table 1and 2.

Table 1: Engine Specification

Model	AX160 HSP
Type	4 stroke, single cylinder, Air cooled engine
No. of cylinders	One
Bore x stroke	68 x 45
Displacement	163 cm^3
Fuel	Petrol start = petrol run; kerosene run
Brake S.F.C	370 g/kwh
Rated output	2.83kw @ 3600 rpm
Maximum torque	10.3 Nm @ 2500 rpm
Compression ratio	9.0:1
Rated speed	3600rpm
Weight	15.1 kg

Table 2: Properties of Fuel

Fuel Properties	Petrol	Kerosene
Calorific value, kj/kg	45000	45000
Octane number	90	15-20
Cetane number	20	----
Density, kg/m3	750	730
Lower heating value, MJ/kg	42.9	43.1
Specific gravity	0.82	0.820
Flash point(^{0}c)	22	37-65
Pour point(^{0}c)	-4 to -20	-47
Boiling point(^{0}c)	80-225	150-300
Viscosity	1.5-4 poise	0.0164

Experimental Setup

The performance test of the engine is done using the EDDY CURRENT DYNAMOMETER for petrol start – petrol run and petrol start – kerosene run, as shown in figure 2. The test procedure; start the engine and weight till it fully warmed up and reach the speed of 3600rpm. The uncertainty of engine speed ±72rpm. The petrol was injected into the air, so as to obtain the combustion by volume in the rich mixture. The spark timing has been constant throughout the test. The engine parameters like the specific fuel consumption and exhaust emission were recorded as shown in table 3 and 4.

Figure 2: Eddy Current Dynamometer

Table 3: Petrol Start – Petrol Run

Sl. No.	Brake Power in (W)	Time Taken For 10 ml	Total Fuel Consumption in kg/hr	S.F.C in kg/kw - hr	CO (%)	HC (%)	CO2 (%)
1	1100	32.015	0.806247	0.732952	5.70	60.0	3.70
2	1600	26.4	0.977727	0.61108	5.70	51.0	4.10
3	2100	21.76	1.186213	0.564863	4.27	56.0	3.30

Table 4: Petrol Start – Kerosene Run

Sl. No.	Brake Power in (W)	Time Taken For 10 ml	Total Fuel Consumption in kg/hr	S.F.C in kg/kw - hr	CO (%)	HC (%)	CO2 (%)
1	1100	33	0.782182	0.711074	6.01	78.6	4.01
2	1600	26	0.992769	0.620481	6.01	69.6	4.41
3	2100	20	1.2906	0.614571	4.58	74.6	3.61

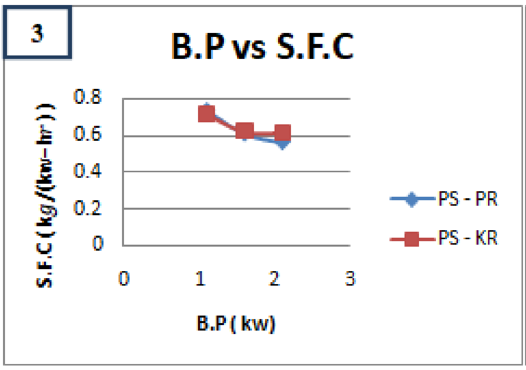
Analytical Discussion

The engine performance parameters are calculated by using the standard formula[13]. The friction power is equal to 1.62 kW and it is calculated by using Williams's method.

- Brake power = 1.1kw
- Fuel consumption, (f_c) = $\frac{Mass\ of\ fuel\ (lit)}{Time\ taken\ (\square r)}$ in $\frac{Kg}{\square r}$
- Specific fuel consumption = $\frac{Fuel\ CONSUPTION}{Brake\ power}$ in $\frac{Kg}{Kw-\square r}$
- Friction power = 1.62 kw
- Indicated power = Friction power + Brake power in kw
- Mechanical efficiency = $\frac{Brake\ power\ (kw)}{Indicated\ power\ (kw)}$ in %
- Brake thermal efficiency = $\frac{Brake\ power}{fc * calorific\ value}$ in %
- Indicated thermal efficiency = $\frac{Indicated\ Power}{fc * calorific\ value}$ in %

RESULTS AND DISCUSSIONS

The existing single cylinder four stroke overhead valve (OHV) spark ignition engine performance and emissions have been studied for petrol start – petrol run and petrol start – kerosene run. The operating parameters like engine speed and compression were kept constant during complete test. Figure 3 Shows the brake power vs. specific fuel consumption for both petrol start – petrol run (ps – pr) and petrol start– kerosene run (ps – kr). Figure 4 shows the brake power vs. mechanical efficiency for both petrol start – petrol run and petrol start – kerosene run. Figure 5 shows the brake power vs. brake thermal efficiency for both petrol start – petrol run and petrol start– kerosene run. Figure 6 shows the brake power vs. indicated thermal efficiency for both petrol start – petrol run and petrol start – kerosene run. Figure 7 Displays CO emission vs. Brake power for both ps – pr and ps – kr. Figure 8 Shows HC emission vs. Brake power for ps – pr and ps – kr. Figure 9 Shows CO_2 emission vs. Brake power for ps – pr and ps – kr.



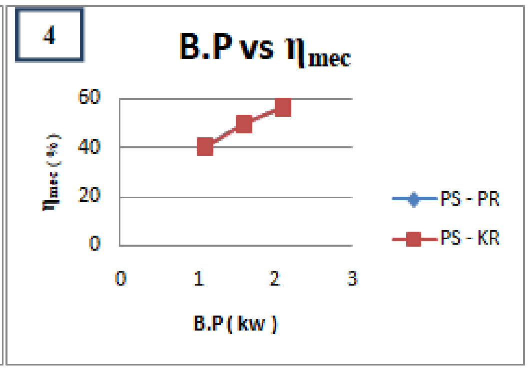


Figure 3 & 4: Brake Power in kWvs Specific Fuel Consumption in $\frac{Kg}{kw-hr}$vs Mechanical Efficiency in %

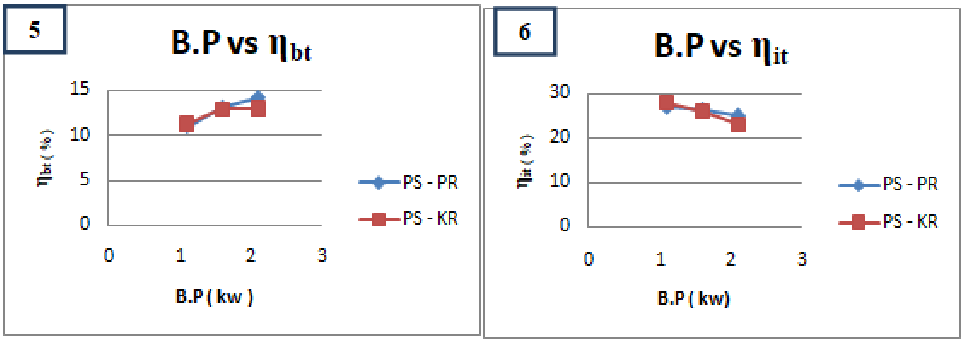


Figure 5 & 6: Brake Power in kw vs Brake Thermal Efficiency in %vs Indicated Thermal Efficiency in %

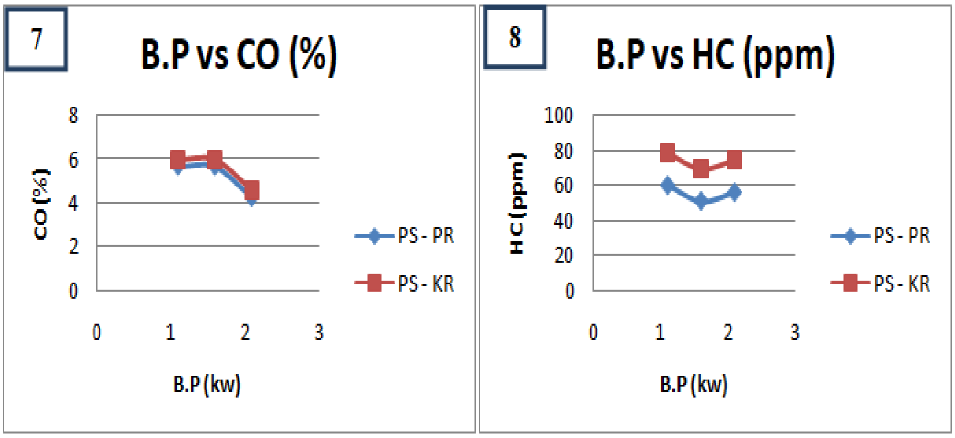


Figure 7& 8: Shows CO Emission vs Brake Power for ps – pr and ps – krvs Brake Power for ps – pr and ps – kr

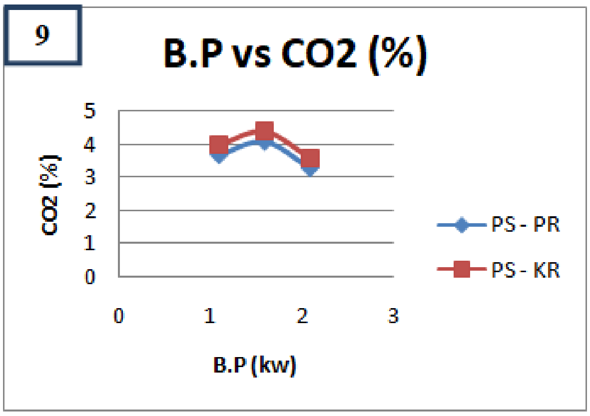


Figure 9: Shows CO2 Emission vs Brake Power for ps – pr and ps - kr

The graph results shows the petrol start – petrol run and petrol start – kerosene run as follows:

50% Load

- Specific fuel consumption almost same.
- Mechanical efficiency is same.
- Brake thermal efficiency almost equal.

- Indicated thermal efficiency almost equal.
- CO content petrol start-petrol run is less than petrol start-kerosene run.
- HC, petrol start-petrol run is less than petrol start-kerosene run.
- CO_2, petrol start-petrol run is slightly less than petrol start-kerosene run.

75% Loading and

- Specific fuel consumption almost same.
- Mechanical efficiency is same.
- Brake thermal efficiency almost equal.
- Indicated thermal efficiency almost equal.
- CO content is almost equal.
- HC, petrol start-petrol run is less than petrol start-kerosene run.
- CO_2, petrol start-petrol run is slightly less than petrol start-kerosene run.

100% Loading

- Specific fuel consumption petrol start-petrol run is less than petrol start-kerosene run.
- Mechanical efficiency is same.
- Brake thermal efficiency start-petrol run is more than petrol start-kerosene run.
- Indicated thermal efficiency start-petrol run is more than petrol start-kerosene run.
- CO content petrol start-petrol run is slightly less than petrol start-kerosene run.
- HC, petrol start-petrol run is less than petrol start-kerosene run.
- CO_2, petrol start-petrol run is slightly less than petrol start-kerosene run.

CONCLUSIONS

In this study, two different fuel types, such as petrol start – petrol run and petrol start - kerosene run are used in single cylinder four stroke overhead valves (OHV) spark ignition engine. Based on the experimental investigation, the engine performance and emission characteristics have been recorded and the analytical calculation was done using the standard formulas, and the obtained values are represented, graphically. The brake power vs. specific fuel consumption, mechanical efficiency, brake thermal efficiency and indicated thermal efficiency are almost same by petrol start – petrol run and petrol start – kerosene run. Also, the emission characteristic such as CO, HC and CO2 are plotted, graphically. The engine performance results concluded the following.

- At 50% load test conducted, specific fuel consumption is almost same in ps- pr and ps- kr,
- At 75 to 100% load, specific fuel consumption is slightly increased in ps-kr.

- At 50, 75, and 100 % test conducted, mechanical efficiency is same in ps-pr and ps-kr.
- At 50% test conducted, brake thermal efficiency is almost same in ps-pr and ps-kr,
- At 75 to 100 %, brake thermal efficiency is slightly decreased in ps-kr, while compared with ps – pr.
- At 50% test conducted, the thermal efficiency is almost same in ps-pr and ps-kr,
- At 75 to 100 %, the thermal efficiency is slightly decreased in ps-kr, while compared with ps-pr.
- When load increases from 50% to 75%, CO emission slightly increases, and from 75% to full load condition, it is decreased. As load increases, the engine efficiency also increases, which leads to decrease in CO emission.
- HC emission decreases with the increase of load from 50% to full load condition, and combustion efficiency is high. So that, HC is decreased.
- CO2 emission is increased from 50% load to 75% load, and decreases from 75% to full load condition. This is due to the chance of complete combustion that happened at the higher loads.

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